Don’t be Baffled by Your Baffle Box

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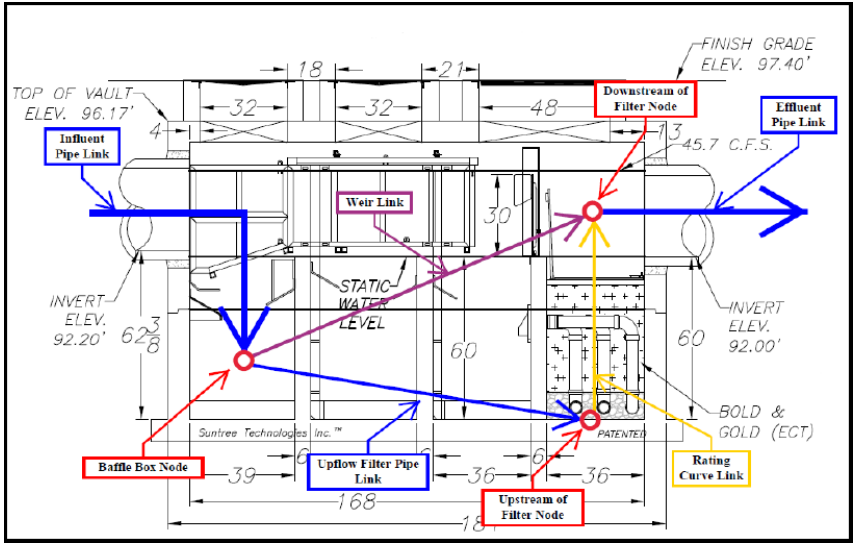
Presentation Outline

- Introduction
- Monitoring Program and Methods
- Results
- Conclusions and Recommendations



Introduction

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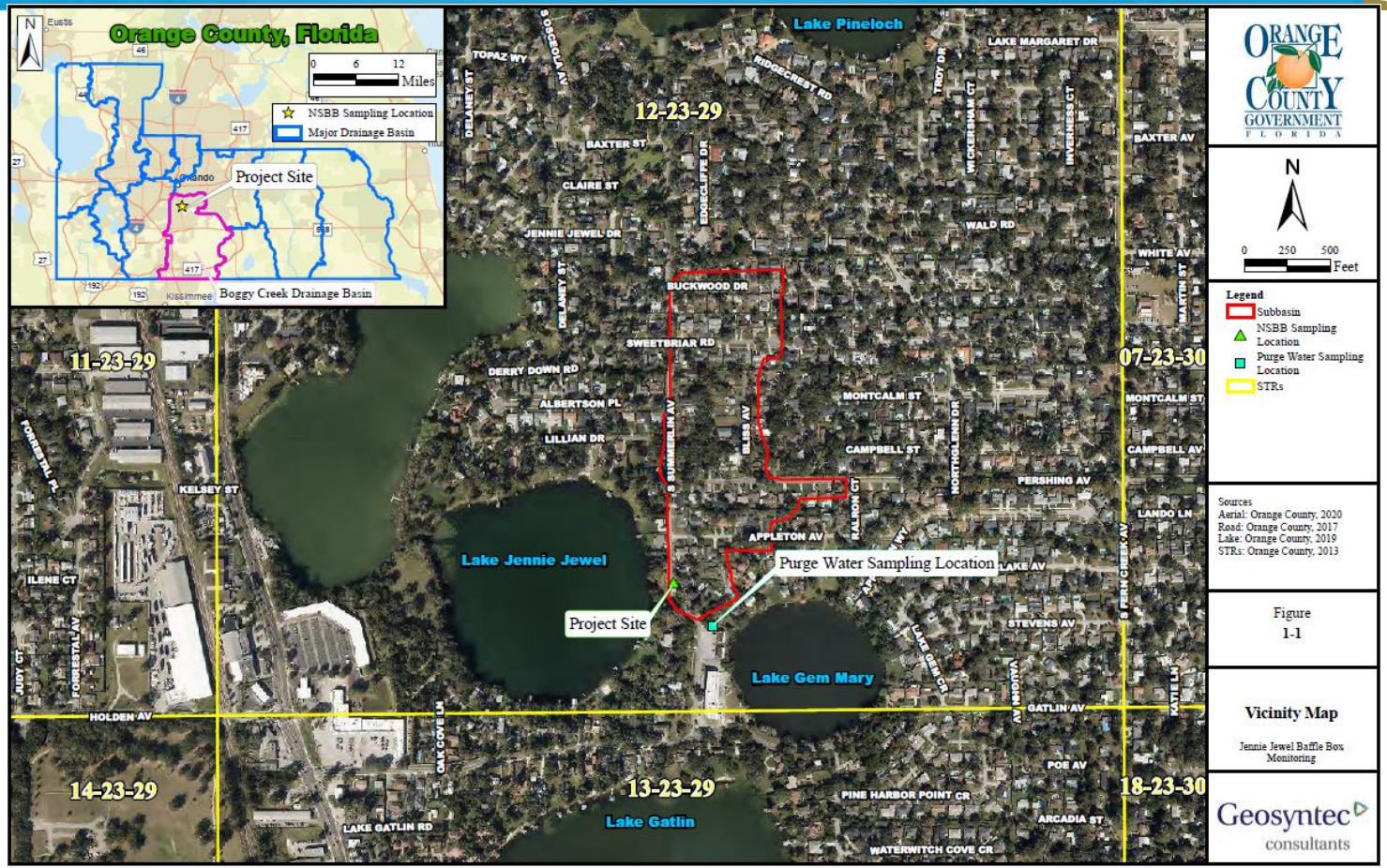
Environmental Protection Division

Introduction

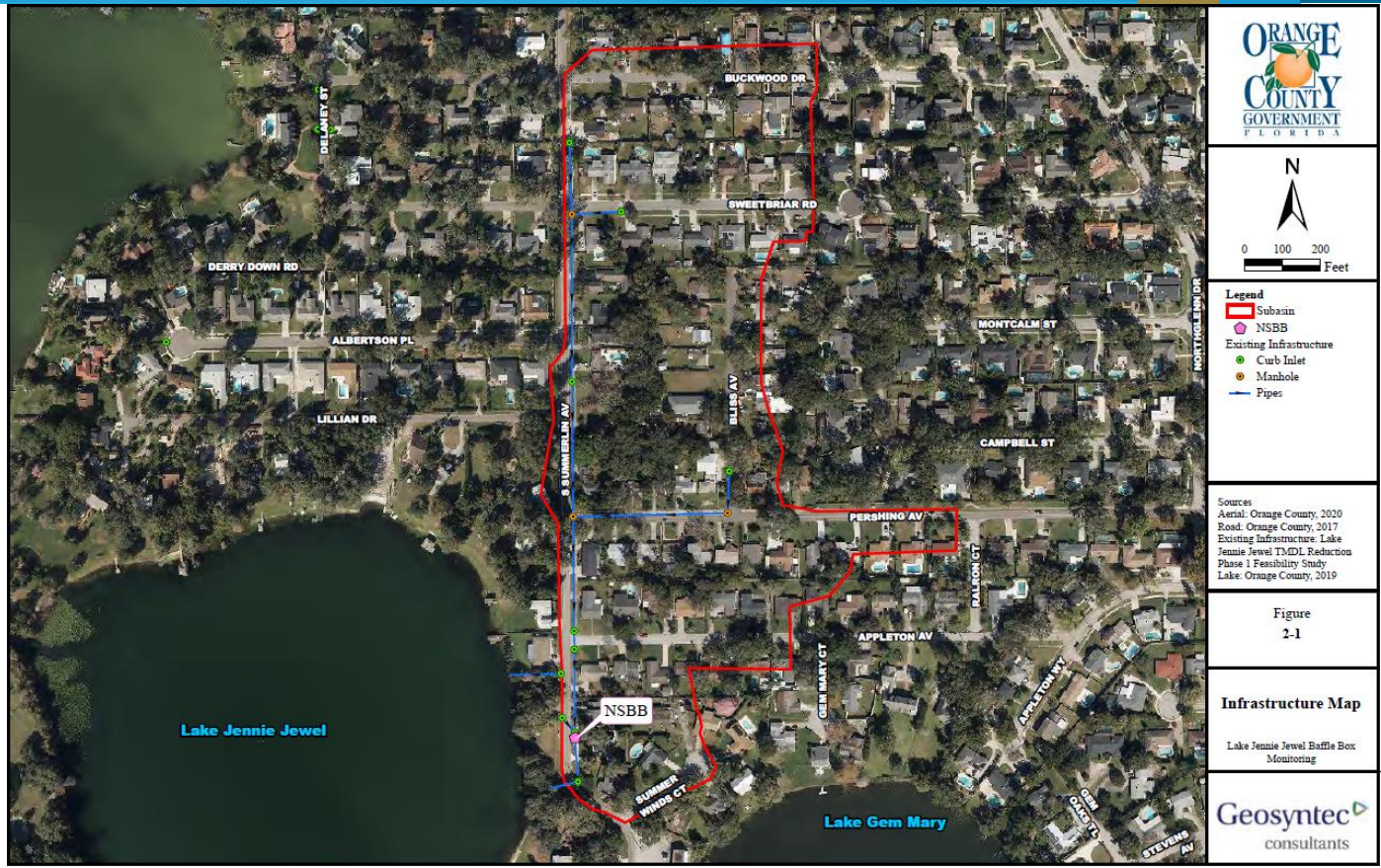
- County installed NSBB with Bold & Gold Upflow Filter
- 27-acre subbasin that outfalls to Lake Jennie Jewel
- Previously no treatment provided to stormwater discharges
- Predominately residential areas within subbasin
- Located within the Boggy Creek Watershed and the Lake Okeechobee BMAP area

Introduction

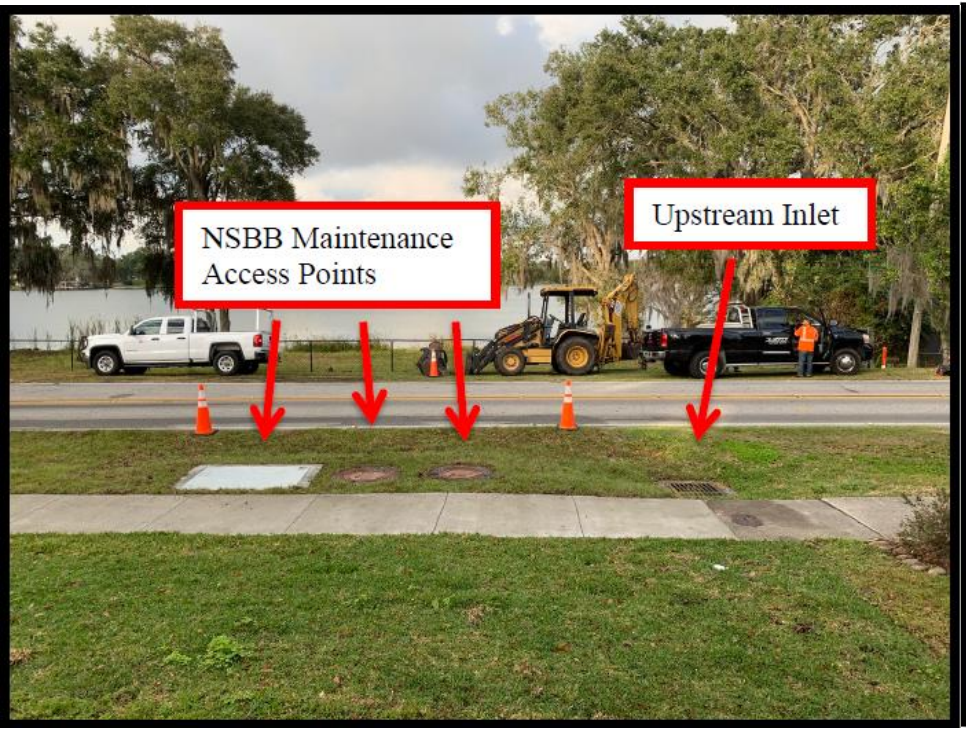


Introduction

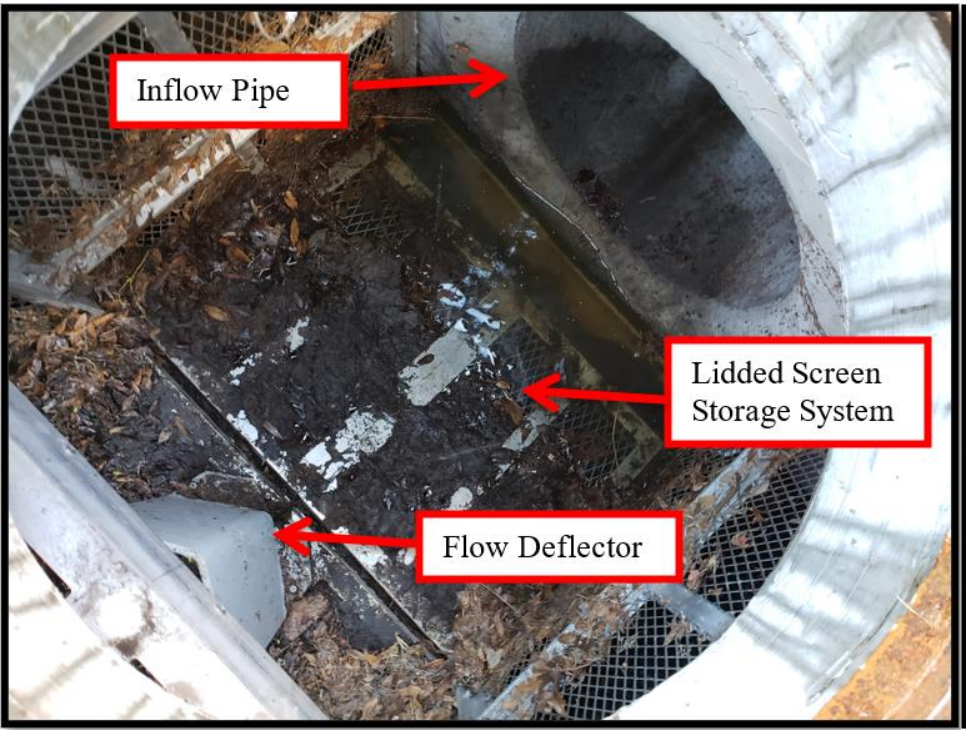
- NSBB originally planned for west side of Summerlin Ave.
- Moved due to conflict and box size had to be reduced

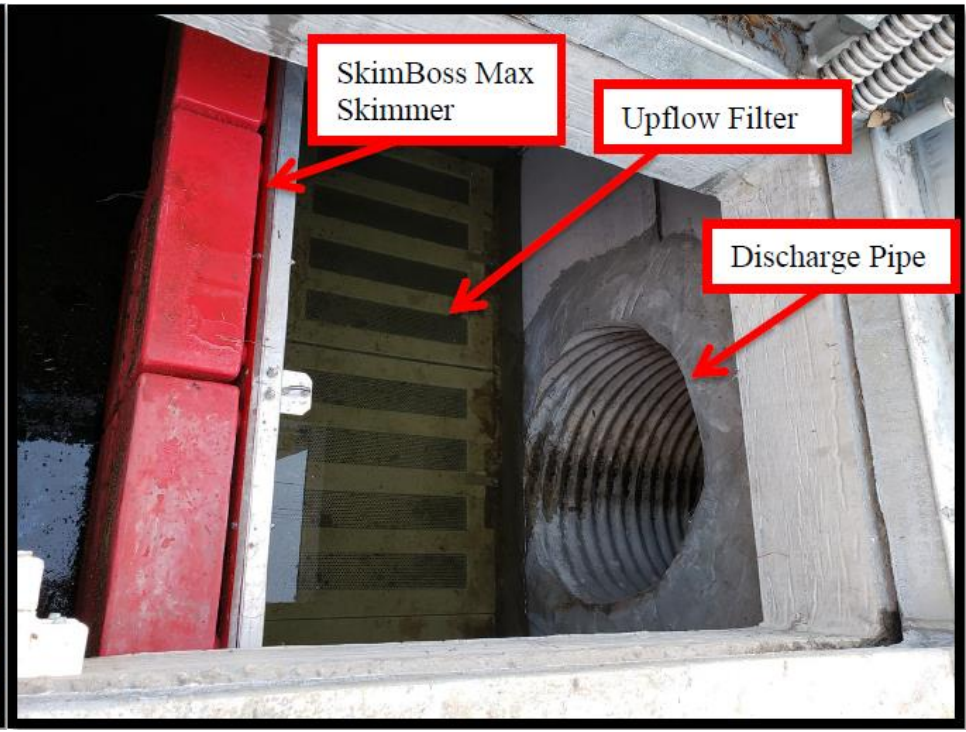


Introduction



Introduction and Project Goals





Monitoring Program and Methods

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Monitoring Program and Methods – QAPP

- Developed project specific QAPP
  - Most important document for sampling project
  - Establishes key personnel and responsibilities
  - Clearly identifies site and project specific methods
    - Sampling techniques and equipment
    - Parameters to sample
    - Laboratory test methods, MDLs, etc.
  - Defines documentation and data quality requirements

Quality Assurance Plan

or

Sampling and Analysis Plan

for

Lake Jennie Jewel Nutrient Separating Baffle Box (NSBB) Efficiency Evaluation

This Quality Assurance Plan (QAP) was prepared in general accordance with the FDEP/EPA requirements specified in *DEP-QA-002/02, "Requirements for Field and Analytical Work Performed for The Department of Environmental Protection Under Contract", Revision April 15, 2002,* and the minimum criteria for Quality Assurance Project Plans specified in *"EPA Requirements for Quality Assurance Project Plans" (EPA QA/R5), EPA/240/B-01/003, March 2001.* This project is being performed for Orange County Environmental Protection Division. This FDEP template was utilized for convenience as an outline for the QAP.

For the remainder of this QAP, text from the FDEP template is provided in 'black' and responses/information provided by Geosyntec are in 'green'.

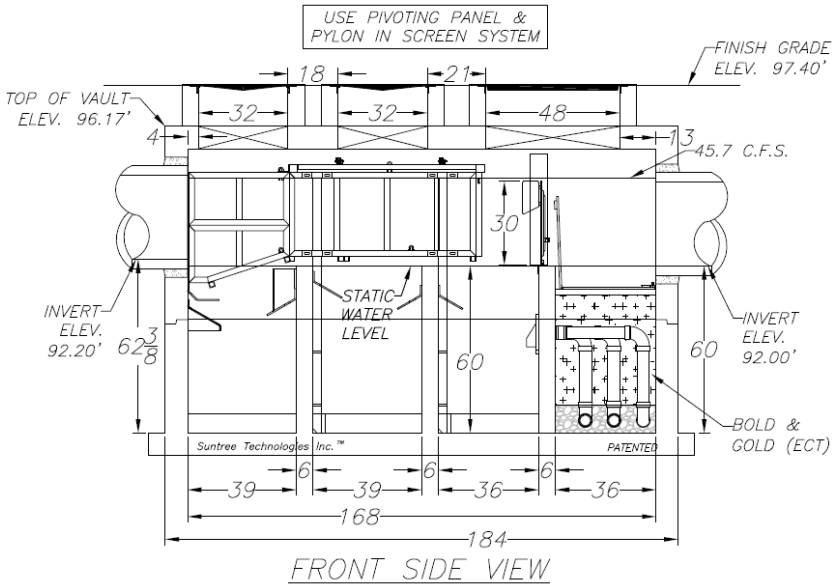
Approving Signatures and Dates

Orange County, Water Sciences – **Mitchell Katz**	Approved:	Date:	09/26/2019
Project Manager – **Mike Hardin**	Approved:	Date:	10-3-2019
Project Principal – **Mark Ellard**	Approved:	Date:	10-3-19
Project Analytics and Testing – **Sherri Payne**	Approved:	Date:	10.02.19
Quality Assurance Manager – **Julia K. Caprio**	Approved:	Date:	9/26/19
Analytics Lab – **Sherri Payne**	Approved:	Date:	10.02.19
Analytics Lab Quality Assurance – **Sherri Payne**	Approved:	Date:	10.02.19

NPS QAP/SAP Template Page 1 DEP-AEQAS/Rev 1-5-16

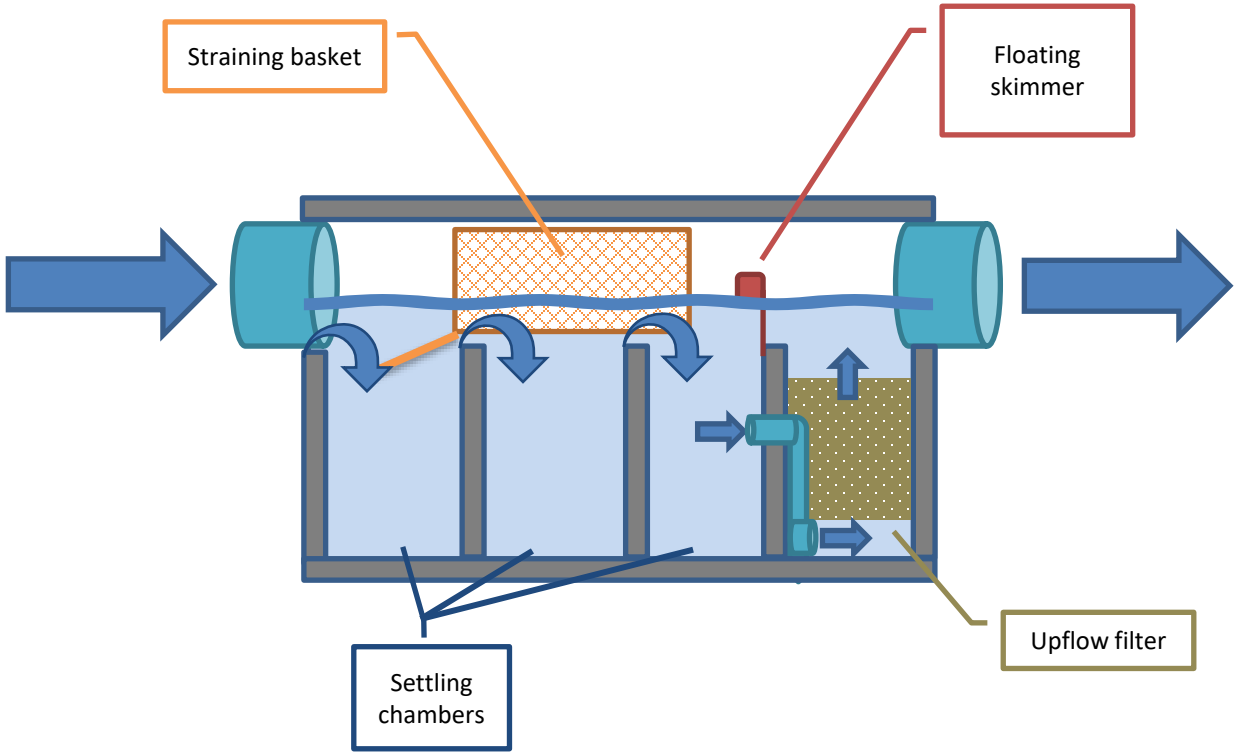
Monitoring Program and Methods – Sampling Approach

- Identify different removal mechanisms to isolate
  - Straining
  - Settling
  - Filtration/biological processes
- Identify different operating conditions
  - Normal operating conditions
  - Bypass conditions
  - Filter loading rate
    - At or below criteria (1 gal/min-sf)
    - Higher than criteria (1 gal/min-sf)



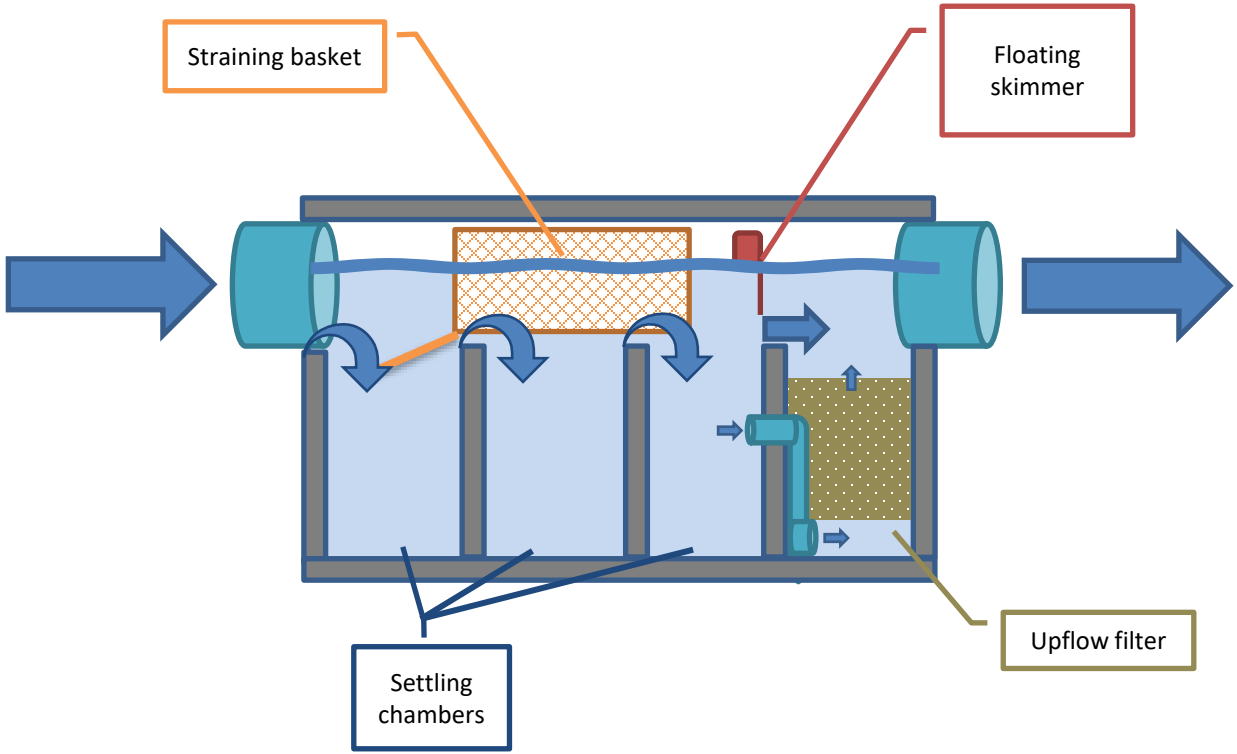
Monitoring Program and Methods – Sampling Approach

Normal operating conditions



Monitoring Program and Methods – Sampling Approach

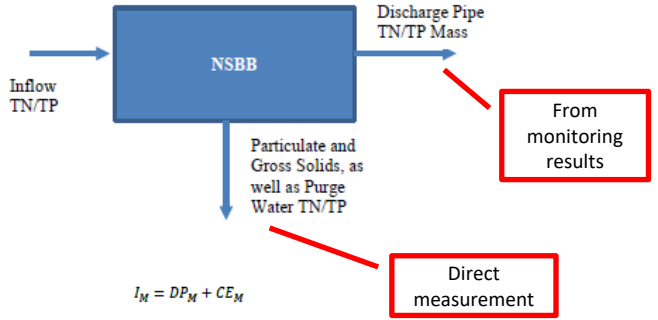
Bypass conditions



Monitoring Program and Methods – Sampling Approach

- Need to account for all pollutant pathways
- Mass balance around the NSBB
  - Influent (dissolved and particulate)
  - Effluent (dissolved)
  - Removed debris and static water
- Combination of autosamplers and discrete event composite sampling (cleaning events)

- Autosamplers are unable to effectively sample large particulates
  - Results in bias
  - Can lead to incorrect results if debris is not evaluated



$I_M = DP_M + CE_M$

Where:

I_M = Total inflow mass of TN/TP flowing to the baffle box (g).

DP_M = Discharge pipe mass of TN/TP flowing out the discharge pipe of the baffle box (g)

CE_M = Cleaning event mass of TN/TP removed from the NSBB (g)

Monitoring Program and Methods

- Storm Sampling
  - Sequential sampling
    - Water elevation and velocity
      - Flow
      - Total volume
      - Determination of bypass conditions
    - TN & TP
  - Composite sampling
    - Water elevation and velocity
      - Flow
      - Total volume
      - Determination of bypass conditions
    - TN & TP
- Maintenance Event Sampling
  - Grab sampling of decanted water
    - 2 grab aliquots, one at the beginning and end of decanting
    - Total volume was documented
    - TN & TP
  - Composite sampling of Solids / collected debris
    - 6 discrete samples were composited
    - TN & TP
    - Total mass of debris documented

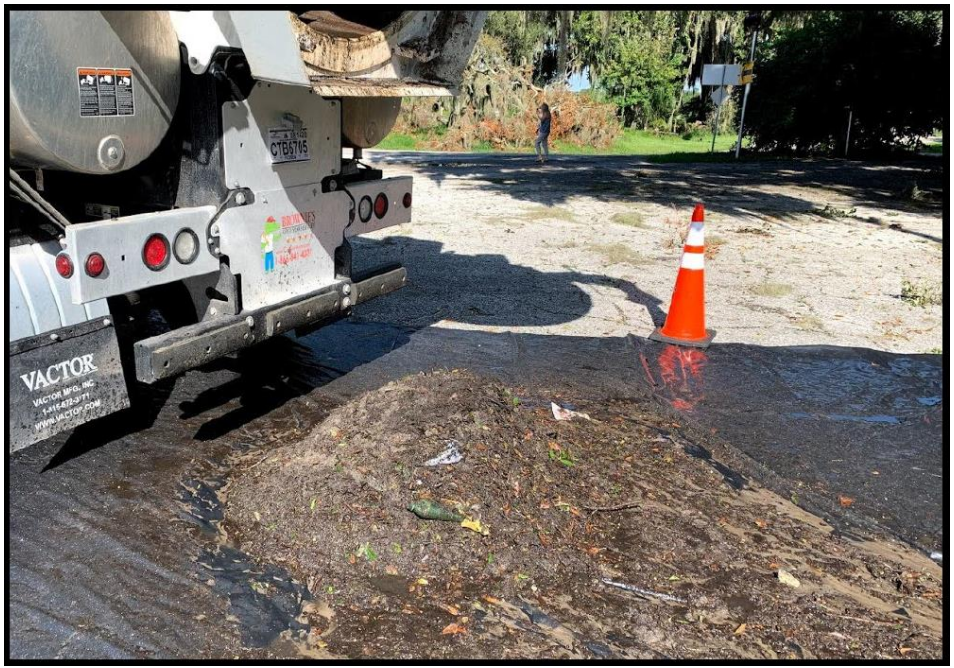
Monitoring Program and Methods – Equipment Installation

- Sampling equipment
  - Three solar-powered ISCO 6712 autosamplers
  - One solar-powered ISCO Signature flow meter
  - One ISCO 730 Water Level sensor
  - One ISCO 2150 area velocity flow sensor
  - One ISCO 674 rain gauge

Monitoring Program and Methods – NSBB Maintenance

- NSBB Maintenance required to ensure proper performance and function
  - Performed using a Vactor 2100
    - Two 800 gallon water drums
      - Rinse water to clean box
    - 2,800 gallon vacuum drum
      - Collect water and debris

Monitoring Program and Methods



Results

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Results – Inflow Quality Characteristics

- True influent concentration not straight forward
  - Stormwater characteristics can hinder effective capture of pollutants via autosampler techniques
    - Size of organic debris can be larger than strainer openings
    - Density of debris can mean debris not evenly distributed throughout the water column
  - Therefore, influent concentration needs to be calculated by performing a mass balance on the NSBB

Results – Inflow Quality Characteristics

- Mass balance around the NSBB
  - Dissolved component is not significant compared to particulate
  - Solids accounted for
    - 84% of TN
    - 74% of TP
    - Will vary based on watershed characteristics

Date	Sediment			Purge Water	
	Total Dry Mass of Solids Collected (lb)	TP Load (lb)	TN Load (lb)	TP load (lb)	TN load (lb)
3/18/2020	7,578	4.70	62.14	0.06	0.43
7/2/2020	1,107	1.06	11.07	0.04	0.20
8/10/2020	1,264	0.63	4.30	0.01	0.07
9/16/2020	729	0.49	3.87	0.03	0.39
10/26/2020	1,418	1.98	3.97	0.06	0.13
11/16/2020	618	0.45	5.81	0.02	0.26
12/21/2020	1,610	0.11	0.01	0.10	0.13
2/23/2021	198	0.18	1.81	0.05	0.24
Total	**14,522**	**9.61**	**94.74**	**0.38**	**1.85**

Resulting Inflow Concentrations:

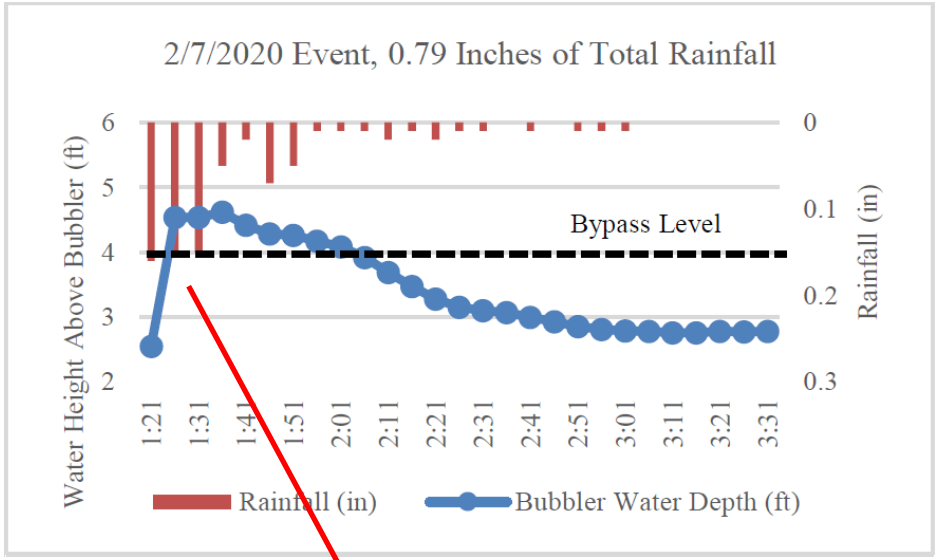
TN = 7.95 mg/L

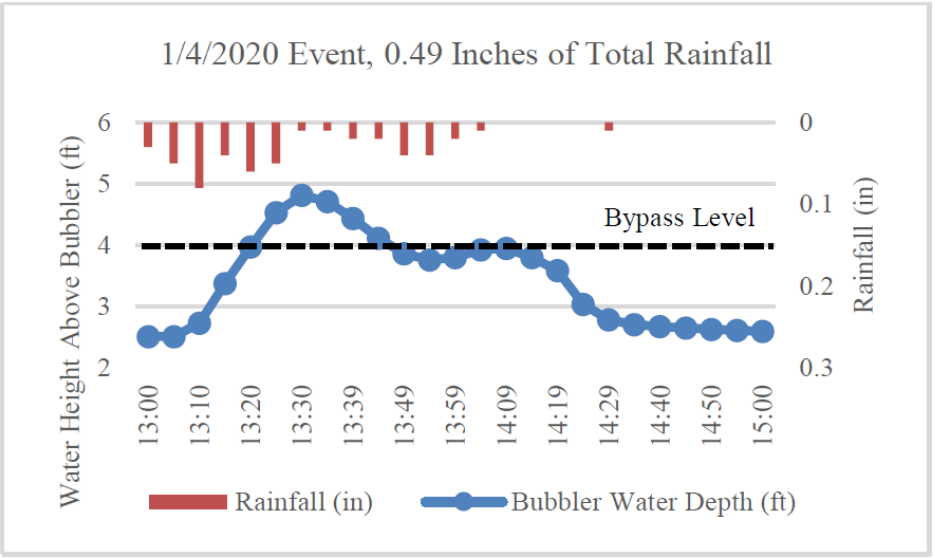
TP = 0.93 mg/L

Results – Hydraulic and Hydrologic Analysis

- Detailed H&H analysis performed to understand flow conditions in NSBB
  - Extent of flashy flow conditions
  - Extent of system bypass
    - Anytime water level above approximately 3.95 ft
    - Results in no treatment except straining via NSBB and settling of large grit
  - Critical to understand these flow conditions due to how much they impact performance

Results – Hydraulic and Hydrologic Analysis



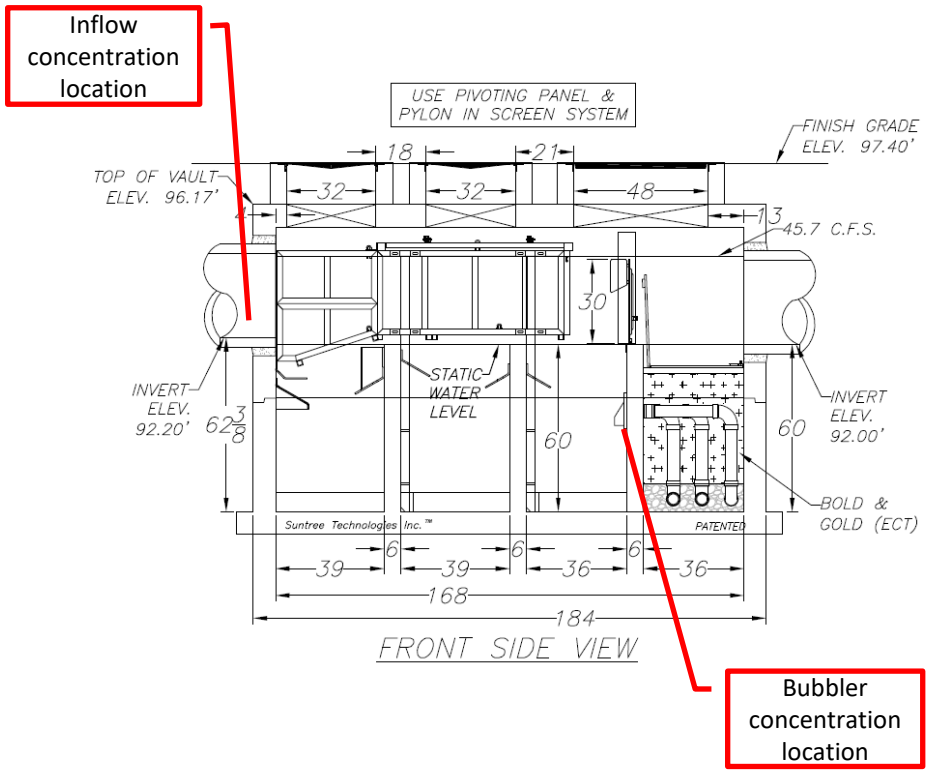


Results – Water Quality Improvement Analysis

- BMP Treatment Train
  - NSBB in series with an upflow filter
  - NSBB provides particulate and gross solids removal
    - Not expected to provide significant dissolved pollutant removal
    - May show export in watersheds with significant tree canopy/organics source due to degradation
  - Upflow filter provides fine particulate and dissolved pollutant removal
    - Fine particles via straining and depth filtration
    - Nutrients via adsorption and biological processes

Results – Water Quality Improvement Analysis: Baffle Box

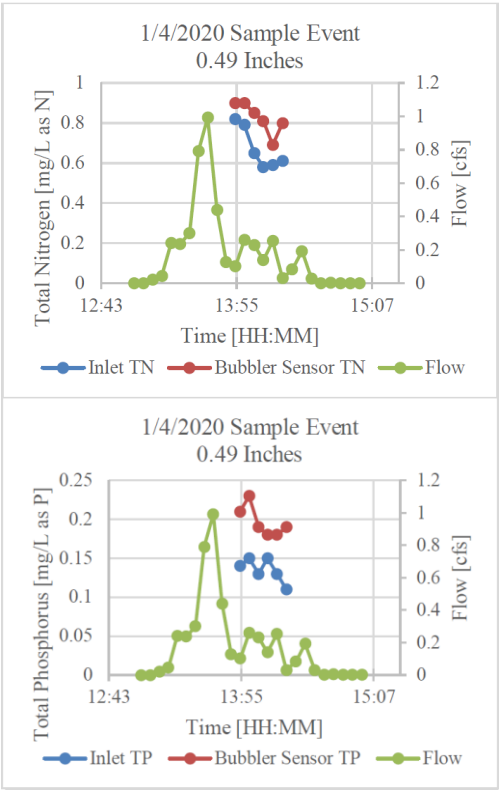
- Evaluate baffle box removal for dissolved TN and TP
  - Based on difference between inflow concentration and bubbler concentration
    - Sequential
    - Composite



Results – Water Quality Improvement Analysis: Baffle Box

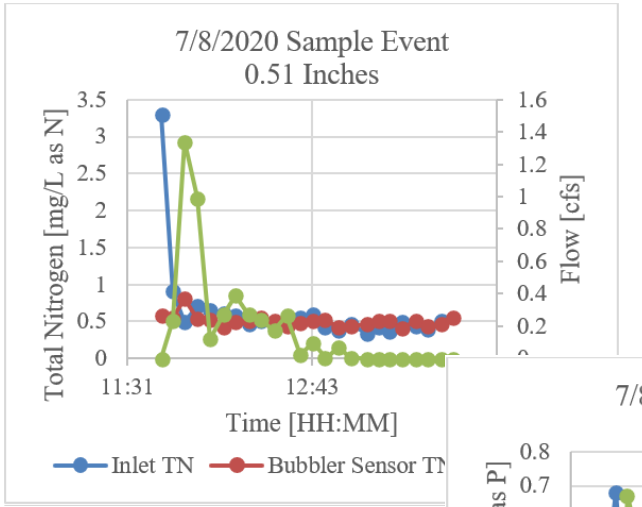
- Dissolved TN and TP differences examined
  - Results showed dissolved concentrations higher at bubbler sensor for some storm events
    - May be due to flushing of nutrients released from sediments and organic debris
    - May be due to sample pairs not representing the same slug of water
    - May be due to location of bubbler sample location (lower in the water column so potential for more sediment impacts)
  - This was not consistent across all storm events

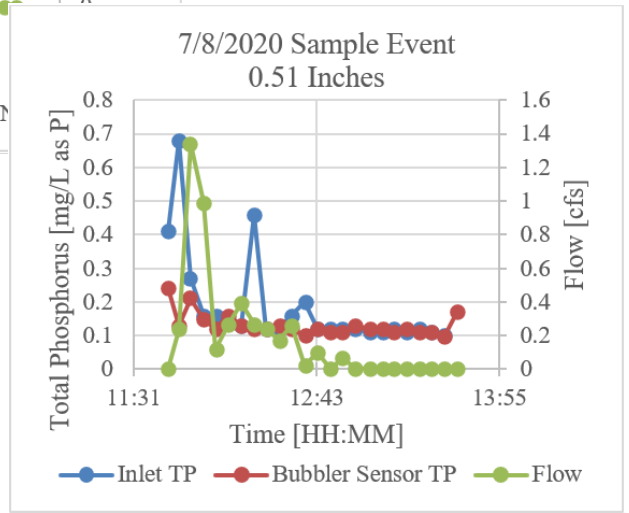
Collected during non-bypass conditions



Results – Water Quality Improvement Analysis: Baffle Box

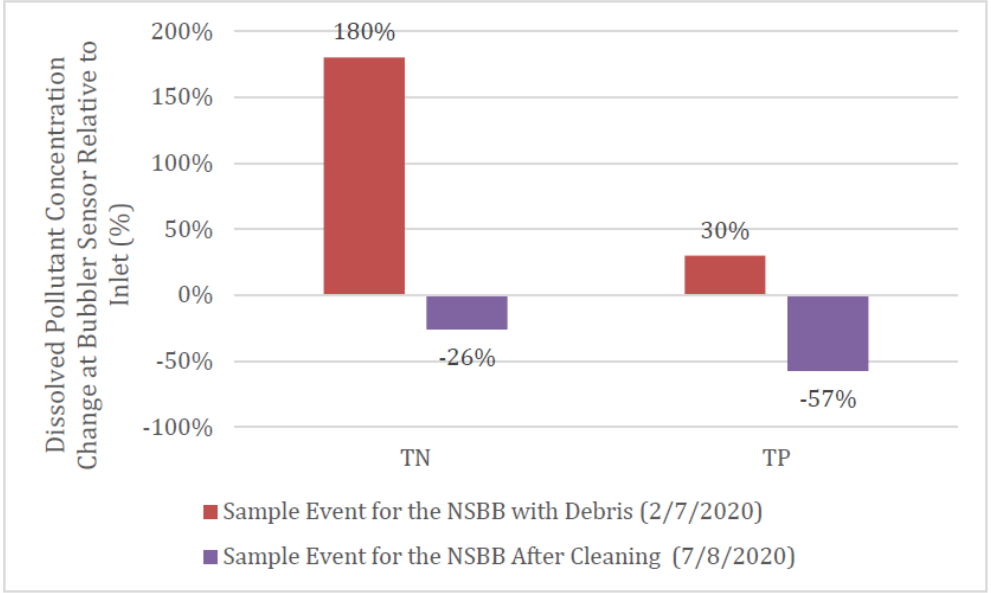
- Look at Sequential results for bypass and non-bypass
  - Shows clear first flush effect
  - During first flush influent higher than bubbler
  - Concentrations similar after





Results – Water Quality Improvement Analysis: Baffle Box Maintenance

- Maintenance impacts were observed
  - Removal appears to be better after cleaning (negative = good)
  - Accumulated debris can convert from particulate to dissolved, thus apparent pollutant generation

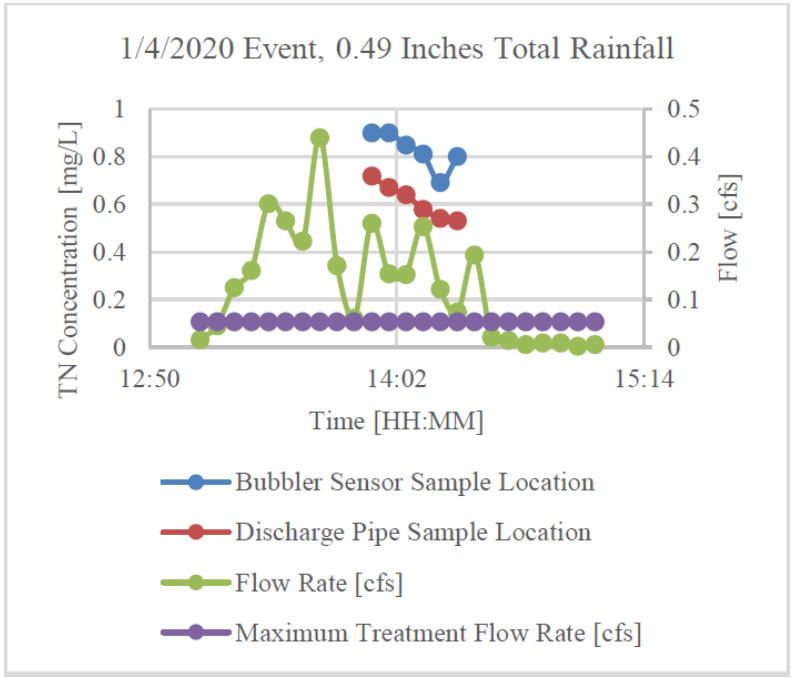


Results – Water Quality Improvement Analysis: Upflow Filter

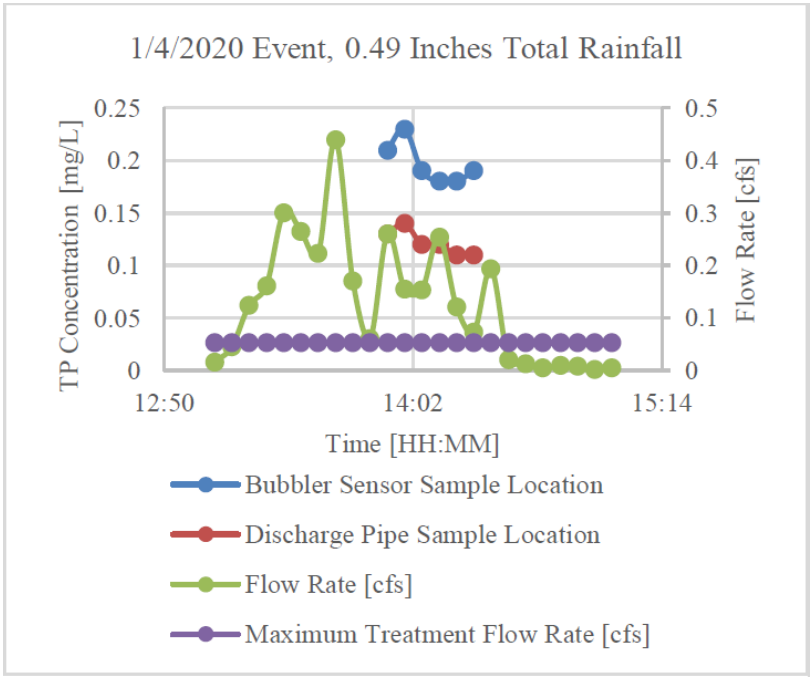
- Upflow filter pollutant removal determination
  - Difference in concentrations between bubbler sensor and effluent
  - Two conditions relevant for performance evaluation
    - NSBB in non-bypass mode
    - Appropriate contact time with the media
      - Determined to be 0.053 cfs based on filter size and media type

Results – Water Quality Improvement Analysis: Upflow Filter

- TN



- TP



Results – Water Quality Improvement Analysis: Upflow Filter

- Upflow filter performance
  - Note that acceptable flow conditions were very rarely observed through the filter
  - TN removal
    - Average for each storm ranged from -19% to 54%
    - Overall average for all storms = 16%
  - TP removal
    - Average for each storm ranged from -9% to 38%
    - Overall average for all storms = 15%

Results – Water Quality Improvement Analysis: NSBB Treatment Train

- Overall pollutant removal

$$Overall\ Pollutant\ Removal = \frac{C_T \times V_T - V_T \times C_{Discharge}}{C_T \times V_T}$$

Where:

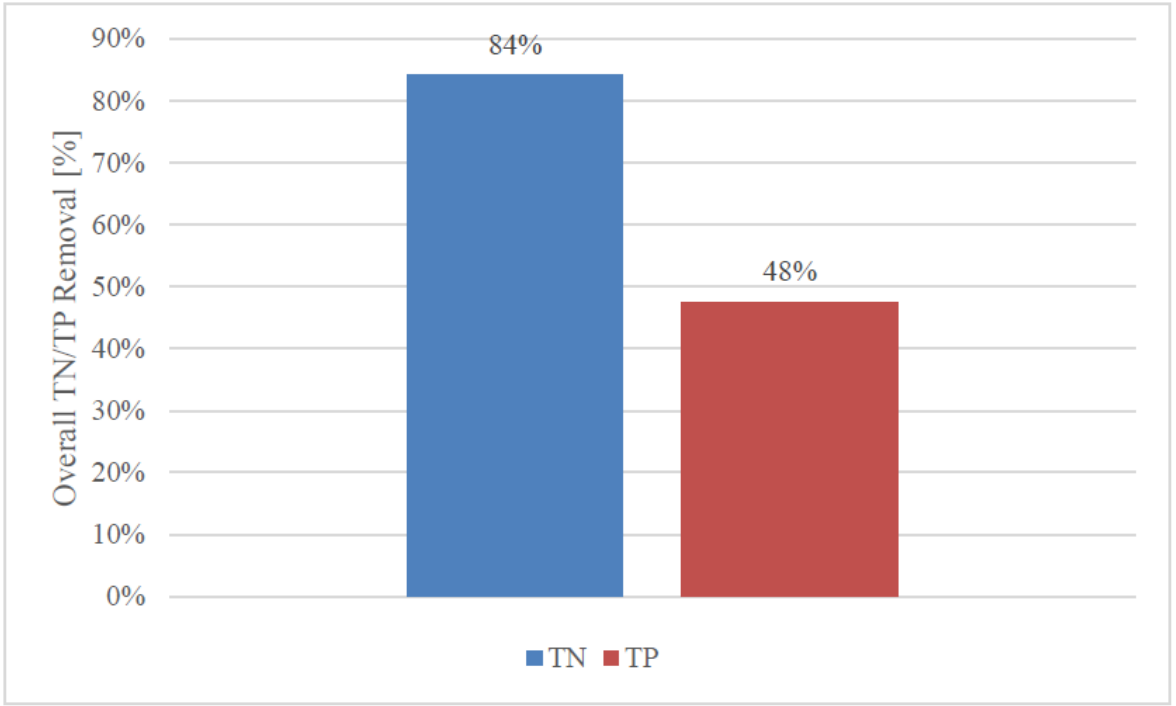
C_T = Theoretical influent concentration of TN/TP (mg/L), which was calculated in **Section 4.1.2**

V_T = The total runoff volume discharged to the lake as measured by the AV sensor in the discharge pipe. This was calculated as 6,654,697 L

$C_{Discharge}$ = The average dissolved TN/TP concentrations at the discharge pipe (mg/L)

Results – Water Quality Improvement Analysis: NSBB Treatment Train

- Overall pollutant removal



Conclusions and Recommendations

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Conclusions

- NSBB undersized for watershed
  - Flashy conditions
  - Frequent bypassing (~82% of total inflow)
    - Shows the importance thorough modeling during design
  - It was noted that due to site conditions the original design had to be changed resulting in a smaller system
- Main source of pollutant mass was particulate and gross solids (large organic matter)
  - Autosamplers not effective at collecting this component of loading
  - Accounted for ~84% of the TN and ~74% of the TP
  - A theoretical influent concentration was determined
    - TN = 7.95 mg/L
    - TP = 0.93 mg/L
    - Significantly higher than typical residential land use EMCs

Conclusions

- Upflow filter undersized for flow conditions
  - Max treatment flow rate of 0.053 CFS
  - Most flow through filter too fast to ensure contact time
  - Sequential sampling average removal
    - TN = 16%
    - TP = 15%
  - Composite sampling average removal
    - TN = 20%
    - TP = 13%

Conclusions

- Overall removals
  - Includes particulate (NSBB) and dissolved (upflow filter)
  - TN = 84% or 72.5 lb/yr
  - TP = 48% or 7.5 lb/yr
  - Most of removal associated with solids removal due to NSBB
- NSBB maintenance critical to system performance

Recommendations

- Perform a more robust modeling approach to better represent the watershed
  - H&H model should include design storms and smaller more frequent storms
  - Leverage Green-Ampt method for rainfall excess estimation
  - Ensure proper accounting for IA and DCIA
  - Model the NSBB components

Recommendations

- Perform ongoing monitoring
  - Flow and water quality
  - Inflow, upflow of filter, outflow, collected debris
  - Monitor different sized systems
  - Collect data on mass of debris collected relative to rainfall and season

With Gratitude …

- Orange County Board of County Commissioners
  - For funding Water Quality Improvement in Orange County
- Orange County Environmental Protection Division
  - For allocating resources to Water Sciences
    - David Jones, PE, Division Manager
    - Julie Bortles, Environmental Program Administrator
- Copies of the final report can be:
  - Downloaded from The Orange County Water Atlas: https://orange.wateratlas.usf.edu/
  - Requested by emailing: mitchell.katz@ocfl.net
- Thank you for participating in the 38th Annual EWRI Water Resources Seminar!

Questions?

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